

NASA TM X- 70432

**INTERIM FLIGHT REPORT
INTERPLANETARY MONITORING PLATFORM
IMP III-EXPLORER XXVIII**

(NASA-TM-X-70432) INTERPLANETARY
MONITORING PLATFORM: IMP 3 EXPLORER 28
Interim Flight Report (NASA) 40 p

N73-73390

00/99 10699
Unclas

MARCH 1966

 **GODDARD SPACE FLIGHT CENTER**
GREENBELT, MD.

INTERIM FLIGHT REPORT
INTERPLANETARY MONITORING PLATFORM
IMP III - EXPLORER XXVIII

By

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March

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ABSTRACT

The third IMP spacecraft, launched 29 May 1965 continues to operate providing abundant scientific data on the Magnetosphere, Shock Wave and Interplanetary Space.

The achieved orbit—apogee about 40 Re, was satisfactory and spacecraft performance is good although the failure of two of nine experiments compromises the solar plasma studies.

The launch, orbit, spacecraft attitude, and performance are discussed based on the first six months of data. The spacecraft continues to operate past the 9 month mark and this and future operation will be discussed in a subsequent report.

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INTRODUCTION

IMP III is the third in the series of the Interplanetary Monitoring Platform spacecraft to be launched. It is also the last, presumably, of the original IMP series; later flights of Anchored IMP's, Super IMP's and advanced IMP designs will utilize modifications, extensions and additions to the basic IMP scientific and engineering concepts pioneered by this original series.

IMP I (Explorer XVIII) launched on 26 November 1963, provided the first direct evidence of a collisionless magnetohydrodynamic shock wave surrounding the Earth and its magnetosphere. It also telemetered much data on the nature of the transition region between the magnetopause and shock front; the magnitude, direction, and variations of the interplanetary magnetic field; and on the energy and fluxes of the solar wind and solar and galactic cosmic rays (Reference 1).

IMP II (Explorer XXI) launched on 3 October 1964 attained an apogee of only 51,000 n. miles - insufficient to properly carry on the studies of the interplanetary medium (Reference 3). However much data was obtained from within the magnetosphere and transition region and data analysis and interpretation continues at this writing.

IMP III, launched 18 months after IMP I and about 8 months following IMP II carried the same basic set of nine scientific experiments as its predecessors. The spacecraft itself was nearly the same as the earlier ones with the exception of a few important changes which are described in Appendix A. A summary data or fact sheet for IMP III is contained in Appendix B.

MISSION OBJECTIVES

The objectives of the IMP III spacecraft were similar to but extensions of those of preceeding IMP's:

- To study in detail the radiation environment of cislunar space, and to monitor this region over a significant portion of a solar cycle.
- To study the quiescent properties of the interplanetary magnetic field and its dynamical relationship with particle fluxes from the Sun.
- To extend knowledge of solar-terrestrial relationships.

To achieve these objectives the IMP spacecraft carry nine highly integrated scientific experiments which can be grouped in the following categories:

Cosmic Ray (Solar and Galactic)
Solar Wind
Energetic Particles
Magnetic Fields

The desired orbit is one of high eccentricity with apogee on the order of 30 earth radii. This permits the spacecraft to traverse the Magnetopause and Shock Wave for almost $\pm 90^\circ$ about the Earth - Sun line and yet not spend an excessive period of time just "hanging" in interplanetary space.

Figure 1 shows the direction of the initial apogee positions with respect to the Earth and Sun for the three IMP's. (It should be noted that this chart illustrates the initial apogee positions for the respective launch dates, but not the relative positions of the different satellites.) Relative to the Earth-Sun system, the apogee position "moves" clockwise about the earth on Figure 1.

LAUNCH

The IMP C spacecraft* was launched (Figure 2) from the Eastern Test Range, Cape Kennedy, Florida at 0700:00.048 EST, 29 May 1965.

Lift-off occurred just .05 seconds after the opening of the 60 minute launch window (Reference 4).

*Third IMP spacecraft to be built.

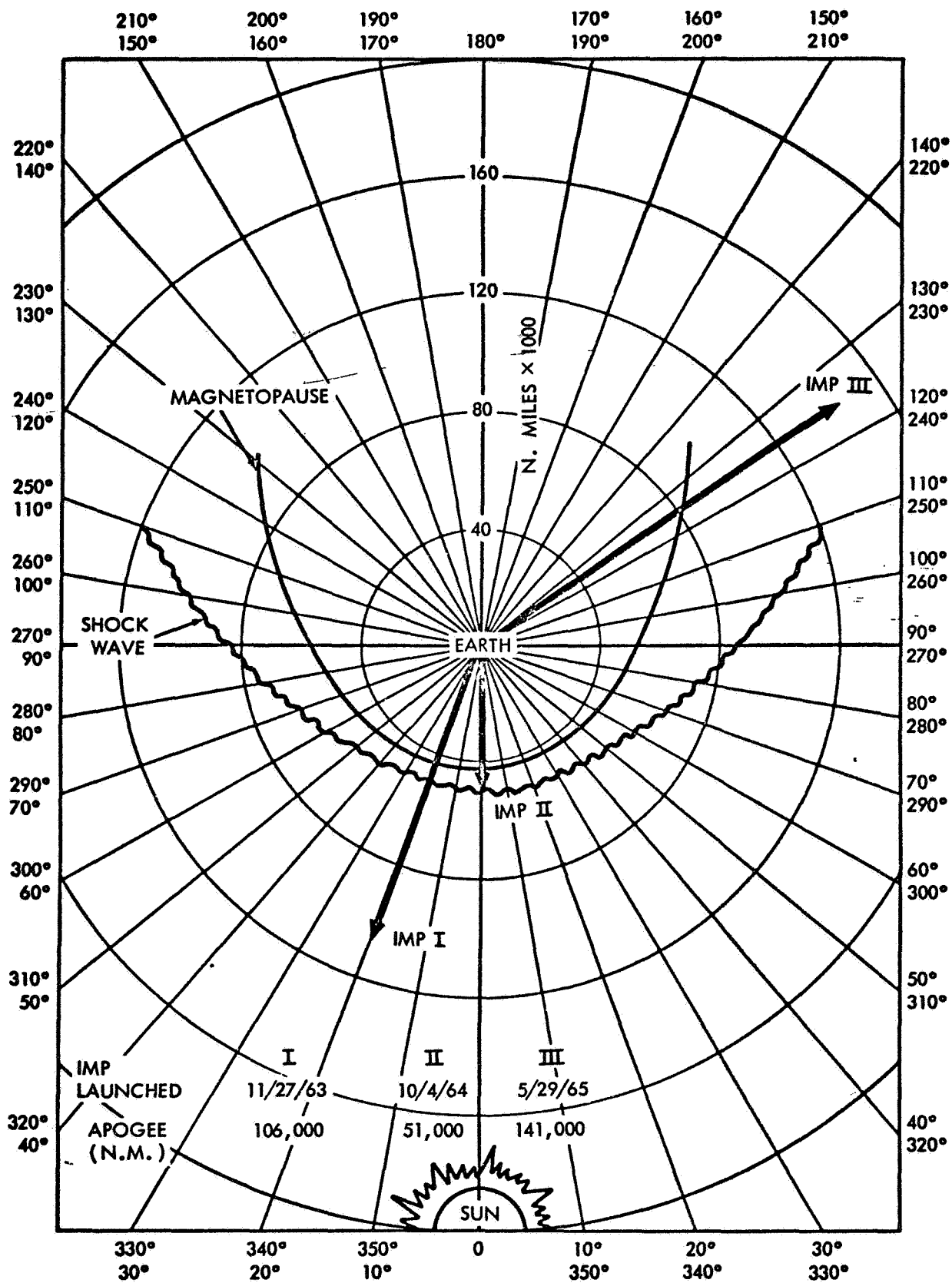


Figure 1 - Projection of Apogee on Ecliptic Plane at the Day of Launch

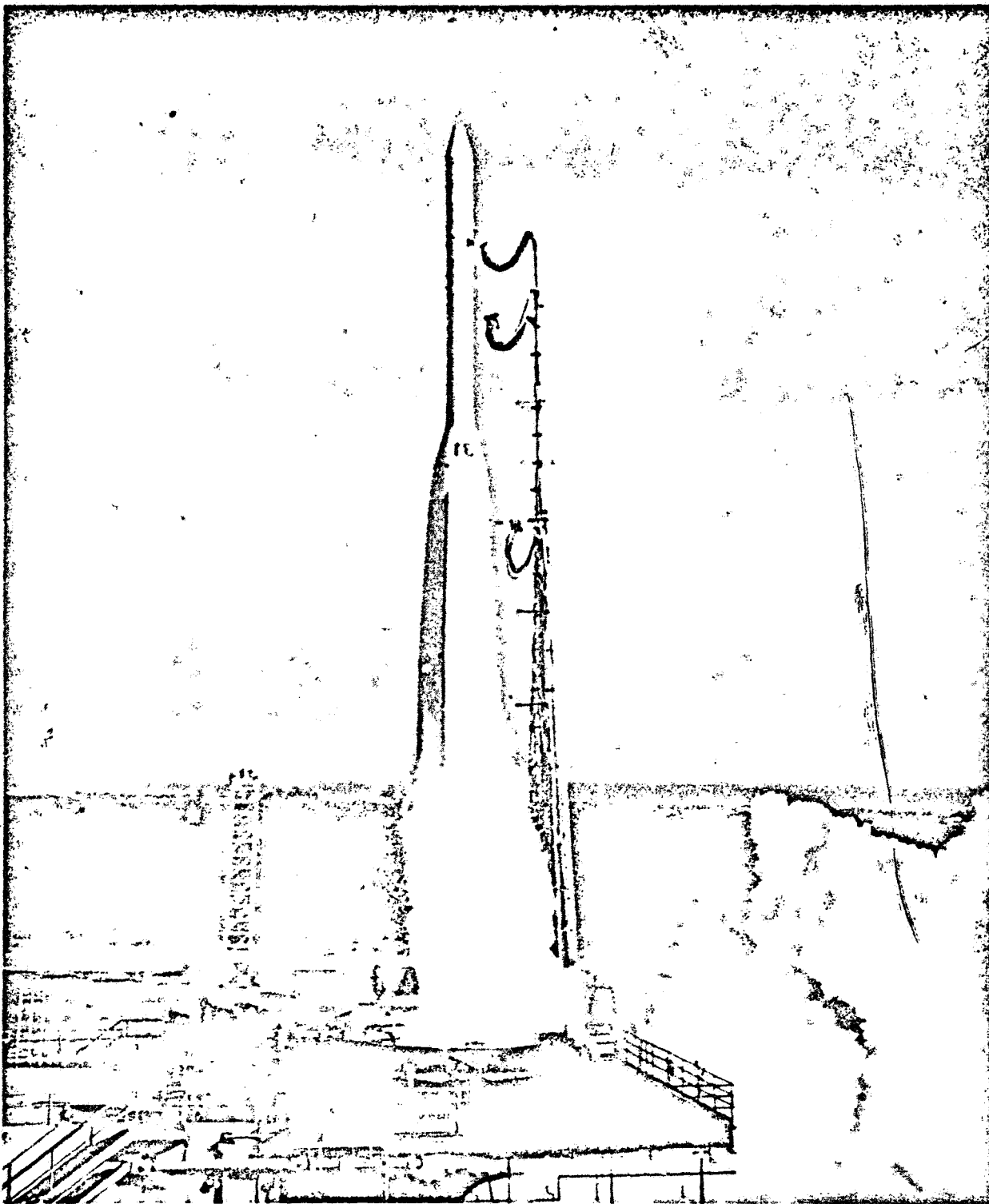


Figure 2 - IMP III - Explorer XXVIII Launching, May 29, 1965

The Delta-31 launch vehicle (type DSV-3C) consisted of a Douglas Aircraft Company liquid propellant THOR booster, an Aerojet General Corporation AJ10-118D liquid propellant second stage, and an Allegheny Ballistics Laboratory X-258-C2 solid propellant third stage. The 30-inch extended low drag aerodynamic fairing was used.

First stage performance was above nominal with the velocity at MECO 372 feet per second higher than nominal (Reference 5).

Second stage performance was near nominal. SECO was commanded by BTL guidance and occurred 11.3 seconds early and at a velocity of 215 feet per second below nominal. The cause of this is due to the selection of trajectory parameters and techniques used to specify the time of SECO commands. Second stage propellant consumption was 95.7% versus a nominal of 98.4% (Reference 5).

The third stage and spacecraft were spun up to 138.25 RPM (predicted was 138.6 RPM).

Third stage performance was above nominal. Injection velocity (reconstructed from orbital data) was 35,712 feet per second or 105 feet per second above nominal (nominal here refers to that inertial velocity which would have produced an apogee altitude of 110,600 nautical miles) (Reference 5).

Orbit injection occurred at $T + 391.27$ seconds and at approximately 22.87° N and 65.59° W from an initial azimuth of 108 degrees from Pad 17B. Injection altitude was 105 nautical miles.

The launch phase sequence of events occurred as planned (Table 1).

During the liftoff of the vehicle, a lanyard on the umbilical mast became entangled with the fairing air conditioner exhaust door. The door was torn from the fairing due to the vertical motion of the vehicle but no other damage or problems are known to have resulted therefrom (Reference 5).

Spacecraft telemetry was received and processed in real time by the IMP trailer at ETR from lift-off until loss of signal as the spacecraft went below the radio horizon (about $T + 400$ seconds); thereafter the telemetry signal was relayed to ETR and thence to the IMP Trailer from the Antigua and Ascension Island downrange tracking stations. The Antigua data was not processable because of receiver problems at that station. This caused a gap in coverage at a crucial time of the launch sequence and prevented the verification of spacecraft separation and extension of the Rb Magnetometer. The Ascension Island data was good

Table 1

Flight Sequence Of Events*
Delta-31, IMP III
29 May 1965

| Event | Seconds From Liftoff | |
|-------------------------------|----------------------|------------|
| | Nominal | Actual |
| Liftoff | 0700:00 EST | 0700:00.05 |
| MECO | 150.5 | 148.1 |
| Stage II Ignition | 154.5 | 152.1 |
| Fairing Ejection | 184.5 | 185.5 |
| SECO | 327.5 | 316.2 |
| Spin-up | 365 | 362.6 |
| Separation | 367 | 364.6 |
| Stage III Ignition | 371 | 368.8 |
| Stage III Burn Out | 393.5 | 392.3 |
| Despin (Yo-Yo) | 420 | 418.3 |
| Erect Solar Paddles | 455 | - |
| Erect F/G Booms | 457 | - |
| Separation | 462 | - |
| Fire Stage III Tumble Rockets | 466.4 | - |

*Reference 5

from about T + 20 minutes until several hours later and provided an excellent "first look" at the data for experimenters.

Following the launch, the Antigua data was reprocessed several times and after careful analysis, it was possible to determine conclusively that separation and Rb Magnetometer extension did occur.

ATTITUDE AND SPIN RATE

During the terminal countdown, the spacecraft telemetry was synchronized with the countdown so that if the launch were to occur on schedule, optical aspect data would be sampled at crucial times. Since liftoff was precisely on time, optical aspect data was obtained at the pre-selected times (Table 2).

Because of the relatively slow sampling rate (once per 82 seconds), the data in Table 2 represent instantaneous data points separated by intervals of 82 seconds. In addition, another set of data (e.g., earth angle) would be required to uniquely determine the spin-axis direction so that conclusions could be drawn regarding the time of occurrence and possible cause of any attitude disturbance.

In short, because of insufficient data, it is not possible to state the cause of the difference in actual spin axis-sun angle from the nominal.

Subsequent optical aspect data provided earth angle information and it then became possible to determine the orientation of the spin axis. This result (Reference 6) is compared with the nominal (Reference 7) orientation in Table 3.

The included angle between the actual spin-axis vector and the nominal is 20.5° and represents the total angular displacement of the spacecraft spin axis from the nominal (but presumed actual) injection velocity vector.

Considerable analysis of the dynamics of an X-258 third stage plus IMP Spacecraft configuration have been done and some important results are summarized here (Reference 8).

Table 2

IMP III Optical Aspect Data During Launch

| Time | Spin Axis - Sun Angle | | Spin Rate | |
|------------------|-----------------------|------------------|-----------|---------|
| | Actual | Nominal | Actual | Nominal |
| After Spin Up | $46 \pm 2^\circ$ | $46 \pm 1^\circ$ | 138 | 138 |
| After Despin | $50 \pm 2^\circ$ | $46 \pm 1^\circ$ | 65 | 75 |
| After Separation | $27 \pm 3^\circ$ | $46 \pm 1^\circ$ | 23.7 | 24 |

Table 3

IMP III Spin Axis Orientation

| | Right Ascension | Declination |
|----------------|------------------------|--------------------|
| Actual | +64.87° | -10.9° |
| Nominal | +82.2° | -23.0° |

1. During third stage burning, "jet damping" maintains the spin axis in the desired direction despite any small thrust misalignment.
2. At third-stage burnout, the spin axis begins to cone about the momentum vector.
3. The non-rigidity of the configuration prevents the cone angle from increasing despite the unfavorable moment of inertia ratio.
4. At Yo-Yo deployment, the cone angle is increased (by a factor of two for IMP III) even though deployment is "symmetrical."
5. Paddle and boom erection probably causes no change.
6. At separation, the spacecraft separates at some position on the cone; the cone angle immediately decreases to about half of its previous value and then damps out because of flexing of the structure.
7. The total displacement of the spin axis from the velocity (and hence momentum) vector could have been cut in half if the spin rate were 200 RPM instead of 138 RPM. Conversely, a lower spin rate, even if it were low enough to permit the elimination of the Yo-Yo despin device would result in a larger angular displacement — hence the value of the Yo-Yo.

The trend of the change of the Spin-Axis Sun Angle and Spin Rate with time is shown in Figure 3. The spin rate change is due to the well known effect of solar radiation pressure acting on the solar paddles; the spin rate decreases when the Sun is shining from below the spacecraft equator and increases when shining from above.

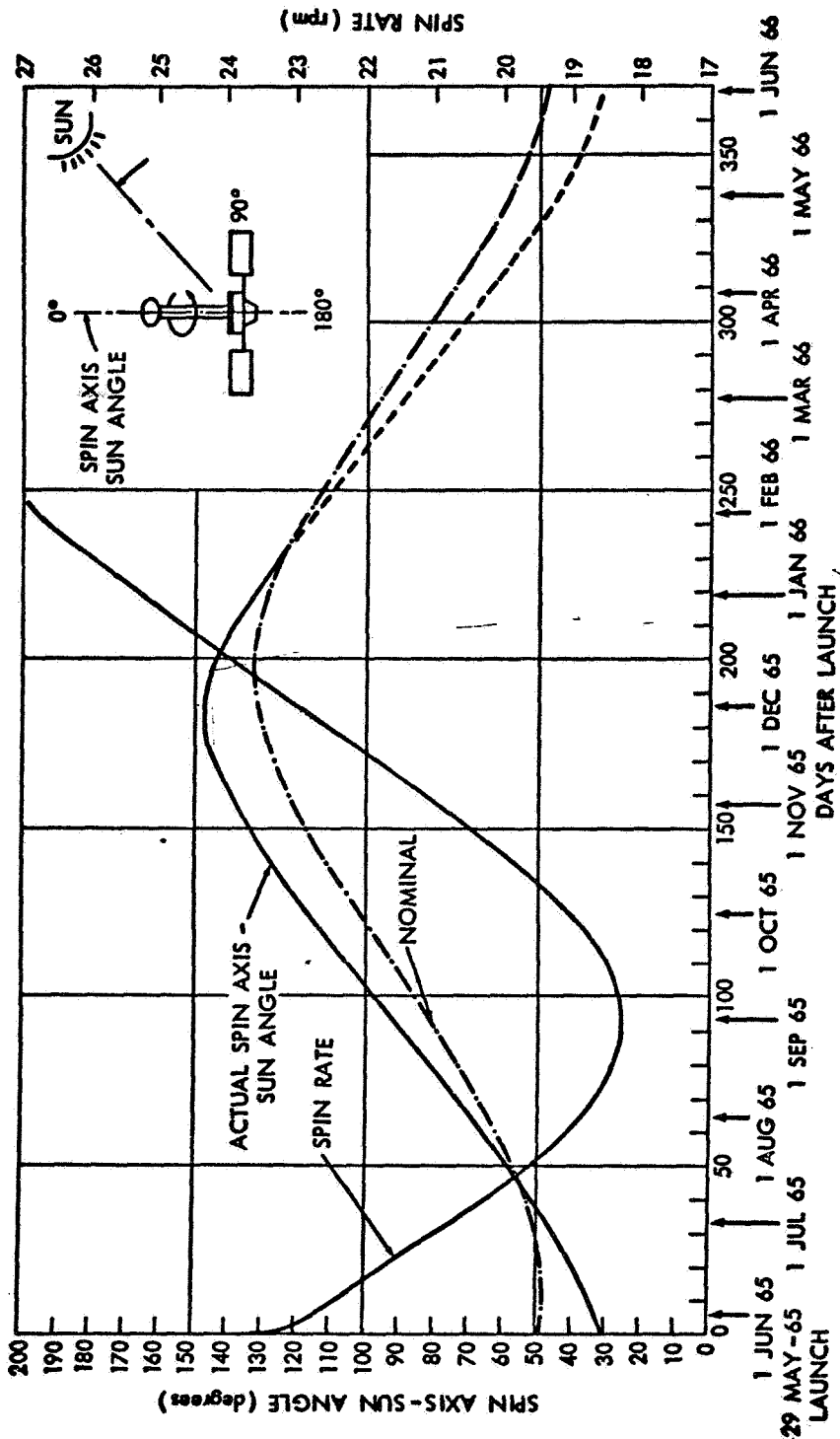


Figure 3 - IMP III - Explorer XXVIII Spin Axis-Sun Angle and Spin Rate vs Time After Launch

No coning of the spacecraft spin axis was observed for the first 3-1/2 months; beginning in mid-September a small amount of coning, less than 3 degrees, was observed (Figure 4). The coning motion decreased and was essentially zero during the month of January 1966. The cause of this phenomena is presently under study.

ORBIT

The IMP III spacecraft was launched into an orbit with characteristics as shown in Table 4.

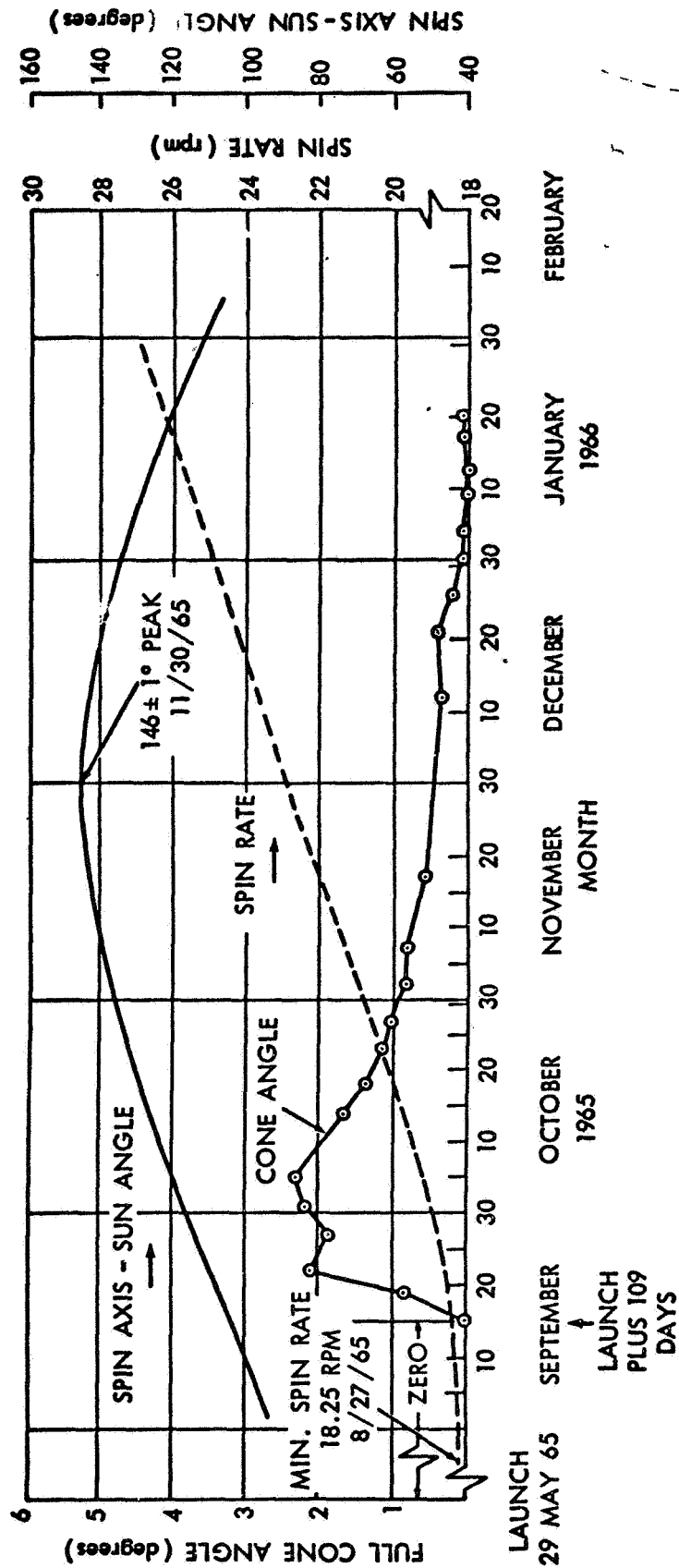
Table 4

IMP III - Explorer XXVIII Orbital Data as Updated After Launch

| Date | Nominal ⁽¹⁾ | 29 May 65 | 9 July 65 |
|--------------------|---|---|---|
| Days After Launch | - | 0 | 41 |
| Apogee Height | | | |
| KM | 204,813 | 260,799.05 | 258,320.23 |
| NM | 110,590 | 140,831.49 | 139,492.92 |
| Perigee Height | | | |
| KM | 189.1 | 203.51 | 3,441.13 |
| NM | 102.1 | 109.90 | 1,858.21 |
| Period | | | |
| Minutes | 5,959.0 | 8,399.51 | 8,434.45 |
| Days & Hrs. | 4 ^d 3 ^h 19 ^m | 5 ^d 19 ^h 59.51 ^m | 5 ^d 20 ^h 34.45 ^m |
| Inclination (Deg.) | 33.01 | 33.84 | 36.28 |
| Eccentricity | 0.940 | 0.952 | 0.928 |
| Data Computed | Delta 31 DTO | 15 June 65 | 8 Sep. 65 |

(1) Nominal orbit computed by DAC shown; Delta Project (GSFC) computed nominal apogee to be 120,000 N.M.

(2) Orbit lifetime computed to be 1086 days; reentry predicted to occur on 18 May 1968.



One of the primary considerations in the selection of the launch window was to provide an increasing perigee height and guarantee a minimum orbital life-time of one year.

Following the launch, a prediction of perigee height for a one year period was generated and is compared with actual tracking data in Figure 5 (Reference 9). The trend of increasing perigee altitude is due to the long term effects of solar and lunar perturbations on the orbit while the high frequency variations are caused by the periodic lunar perturbation.

The orbit lifetime has been calculated to be approximately 3 years with re-entry predicted during May, 1968 (Reference 10).

Shadow Periods

Because of the orientation of the orbit with respect to the Earth-Sun system, the spacecraft was in 100% sunlight during the first 105 days. Beginning with the

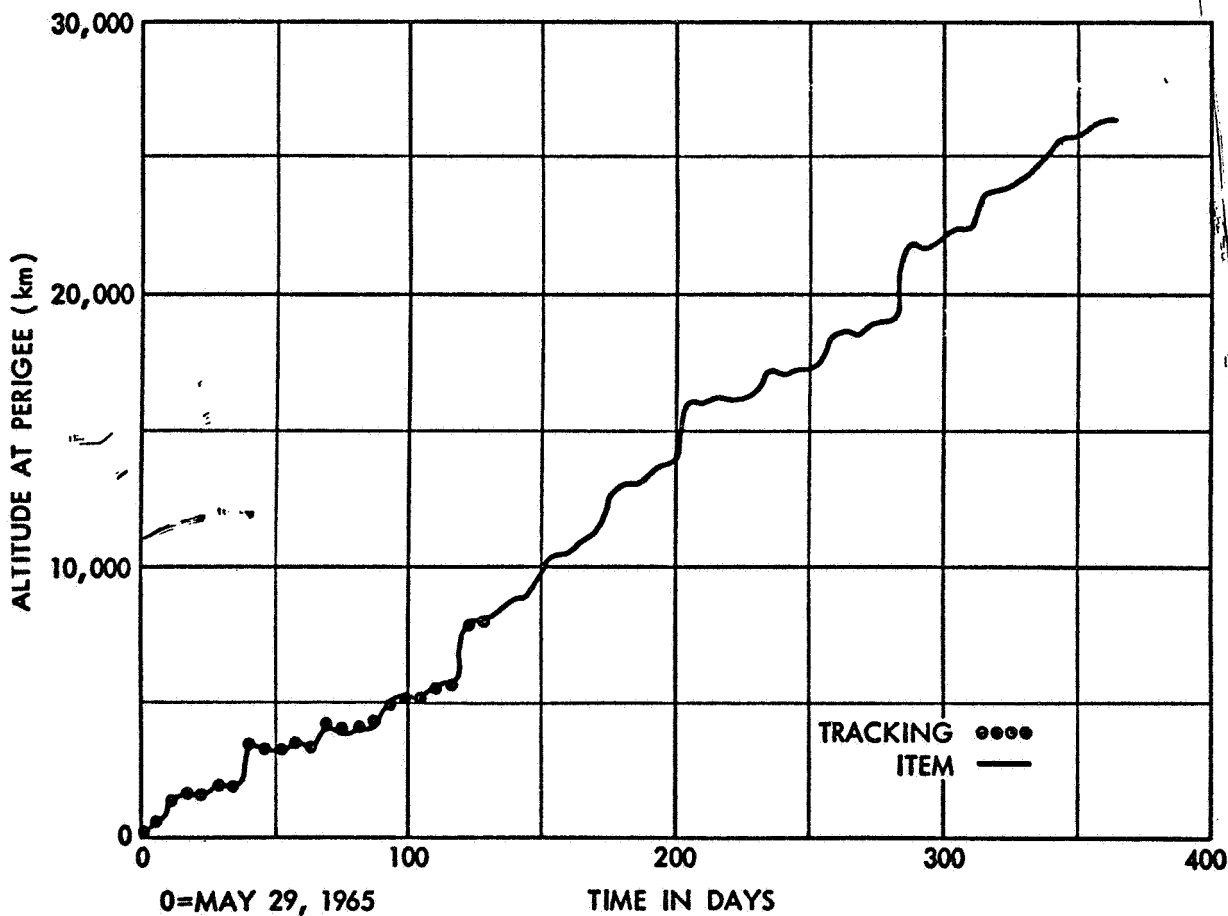


Figure 5 - IMP III Perigee Height Prediction

perigee on day 105 (September 11, 1965) and continuing for each perigee of the next ten orbits (thru 2 November 1965), the spacecraft traversed the shadow of the earth. The shadow data is shown in Table 5.

Following 2 November, the spacecraft re-entered a 100% sunlit orbit which is predicted to continue until 6 April 1966 (some 312 days after launch) when the spacecraft will enter a 5.41 hour shadow (exclusive of penumbra). Thereafter, a 100% sunlit orbit will be experienced until the second series of perigee shadows are encountered in September 1966.

Table 5

IMP III Shadow Data

| Shadow | Date 1965 | Predicted ⁽¹⁾ | | Actual ⁽²⁾ | |
|--------|--------------|--------------------------|--------------------|--------------------------------------|---------------------|
| | | Start Time (U.T.) | Duration (Min.) | Start Time (U.T.) | Duration (Min.)* |
| - | 5/29 | - | 03 | Lift-off Probably Didn't Occur | 03 ⁽³⁾ |
| - | 9/5 | 1409 | 09 | | - |
| 1 | 9/11 | 0932 | 16 | 0935 | 13-1/2 |
| 2 | 9/17 | 0514 | 20 | 0516 | 17-3/4 |
| 3 | 9/22 | 0016 | 23 | ? | ~ 22 |
| 4 | 9/28 | 2120 | 28 | 2121 | 26 |
| 5 | 10/4 | 1708 | 30 | ? | ~ 30 |
| 6 | 10/10 | 1332 | 31 | ? | ~ 31 |
| 7 | 10/16 | 0952 | 30 | 0953 | 31-1/2 |
| 8 | 10/22 | 0533 | 28 | 0533 | 28-1/2 |
| 9 | 10/28 | 0207 | 23 | 0207 | 24-1/2 |
| 10 | 11/2 | None Predicted | | 2253 | 7 |

NOTES: (1) Predicted World Map.

(2) S/C Data where available.

(3) Lift-off thru Fairing Ejection.

SPACECRAFT PERFORMANCE

There have been five spacecraft operational problems reported to date, three of which definitely occurred during the launch phase. Except for these problems, described below, the operation of the spacecraft including most experiments has been and continues to be excellent.

- A serious problem involved the failure of the MIT Plasma Probe Experiment sometime during the launch phase. The MIT Experimenter has reviewed the tapes of the launch phase (Reference 11) but is unable to determine the time of failure. However, there is an indication that the experiment may have been working for a brief period following third-stage burnout and solar paddle erection (which activates the experiment modulation). Within one minute thereafter the data became abnormal. While the scientific data has remained abnormal, calibration and internal temperature measurement data has been valid since lift-off. This has lead the experimenter to suspect a failure of the modulator, although the failure mechanism is not understood at this time.
- A second problem was the failure of Fluxgate B, one of two fluxgate magnetometers which together with the Rubidium Magnetometer comprise the GSFC Magnetic Field Experiment. A review of the data indicates (Reference 12) that F/GB was working properly immediately following spin-up of the spacecraft (to 138 RPM) but was not working following third-stage burnout. This suggests that the failure occurred as a result of vibration and/or acceleration forces during burning of the X-258 third stage. The Experimenter reports that this failure will not seriously detract from the scientific results of the experiment.
- A third problem is the lack of data from the Ames Proton Analyzer. During the initial orbits no solar plasma was observed due to the unfavorable Sun Angle caused by the tip-off of the spacecraft at injection. Later orbits however should have produced solar plasma observations but the experimenter reports no plasma data. The instrument sector generator is operating properly and the lack of data is attributed to a failure of the high voltage power supply or the electrometer amplifier with the former the more likely possibility. (Reference 13).
- The fourth problem concerned two anomalies in the University of Chicago experiment data which were detected immediately following the launch phase. The first, an apparent doubling of the expected counting rates has been resolved by the experimenters and is due to the change in the type of detectors used in the IMP III experiment. The second anomaly involved

a change in the channel number at which one of the pulse height analyzer switches gain. This caused a shift of helium events from high to low gain range. However this problem is not considered to be serious in the interpretation of the data from the experiment (Reference 14).

- The fifth problem encountered has been the occasional loss of the S/C telemetry signal by the STADAN Stations. The duration of the loss of signal (LOS) periods has ranged from 4 minutes to about 1-1/2 hours. From launch thru October, 1965, a period of 5 months, perhaps a dozen or more LOS periods have been recorded; of these, seven have been confirmed or are suspected to be caused by a spurious command off of the S/C transmitter. It is not known whether the false command originates internally or externally to the spacecraft. The remaining LOS periods occur at apogee and are caused by the combination of extreme range and unfavorable station look angles (i.e., low elevation). These have caused a negligible loss of data and are of no consequence.

With regard to the seven spurious command-offs, a total of only about four and one-half hours of data has been lost (about 1/10 of 1%). The source of the off-command is not known but it has been verified that it is not due to Station operational problems since some LOS periods occurred after the removal of the off-command equipment by Station personnel. Suspected possible sources of the off-commands could be a command intended for an other spacecraft which coincidentally trigger's IMP III's transmitter off (considered unlikely) or internally generated voltage transients which could possibly cause a self-shut down (most likely). Reactivation of the spacecraft transmitter is usually accomplished by the first ground station which comes into view of the S/C; hence the variable duration of the LOS periods.

It should be noted that the LOS periods described above are not the same as an undervoltage condition as experienced in the past with IMP's I and II (which causes a shut down of the complete spacecraft for the duration of a recycle period), but rather a condition whereby the transmitter alone is commanded-off. This mode can be readily distinguished by a review of the S/C performance parameter data following re-activation. For the record, no undervoltage turn-offs have occurred as of this writing.

PERFORMANCE PARAMETER IN-FLIGHT DATA

Parameters Measured

One of the 16 frames of the telemetry format is allocated to the measurement of fifteen analog Performance Parameters (PP). Included are the

measurement of four voltages, three currents, seven temperatures, and one calibration point. About thirty measurements of each parameter are made in one hour of operation.

Voltages Measured

- PP1 System Voltage (18.3 volts, normally)
- PP2 Prime Converter + 50 $\pm 1\%$ volts, regulated output
- PP8 Prime Converter + 12 $\pm 1\%$ volts, regulated output
- PP12 Multi-Converter + 7 $\pm 1\%$ volts, regulated output

Currents Measured

- PP3 Battery Charge Current
- PP4 Spacecraft Current (2.0 amps, normally)
- PP9 Solar Paddle Output Current

Temperatures Measured

- PP5 Center Tube
- PP6 Rb Gas Cell
- PP7 Battery
- PP10 Solar Paddle
- PP13 Rb Lamp
- PP14 Prime Converter
- PP15 Transmitter

The location of the voltage and current sensors are shown relative to the IMP power system in Figure 6. The Placement of thermistors is shown in Figure 7.

Performance Parameter data from previous IMP flights as well as the IMP III data, show a gradual in-flight drift of the calibration of the analog oscillators. One of the telemetered parameters (PP11) indicates a single calibration point (0 volts); when this is combined with other considerations it is possible to determine a correction factor which, when applied to the observed data, will result in "adjusted data" which is probably accurate to about ± 1 comb filter numbers ($\sim \pm 1\%$). In general, this means that the data can be corrected so that the voltage data is accurate to about ± 0.1 volts, the current data of PP 4 and 9 to ± 50 ma, PP 3 to ± 10 ma* and the temperature data to $\pm 1^\circ\text{C}$ except for the solar paddle temp (PP 10) which is $\pm 3^\circ\text{C}$.

*Because of the difficulty in obtaining repeatable calibration results and the lack of time prior to launch to complete a thorough analysis, the PP3 tolerance could be in error by as much as a factor of 2.

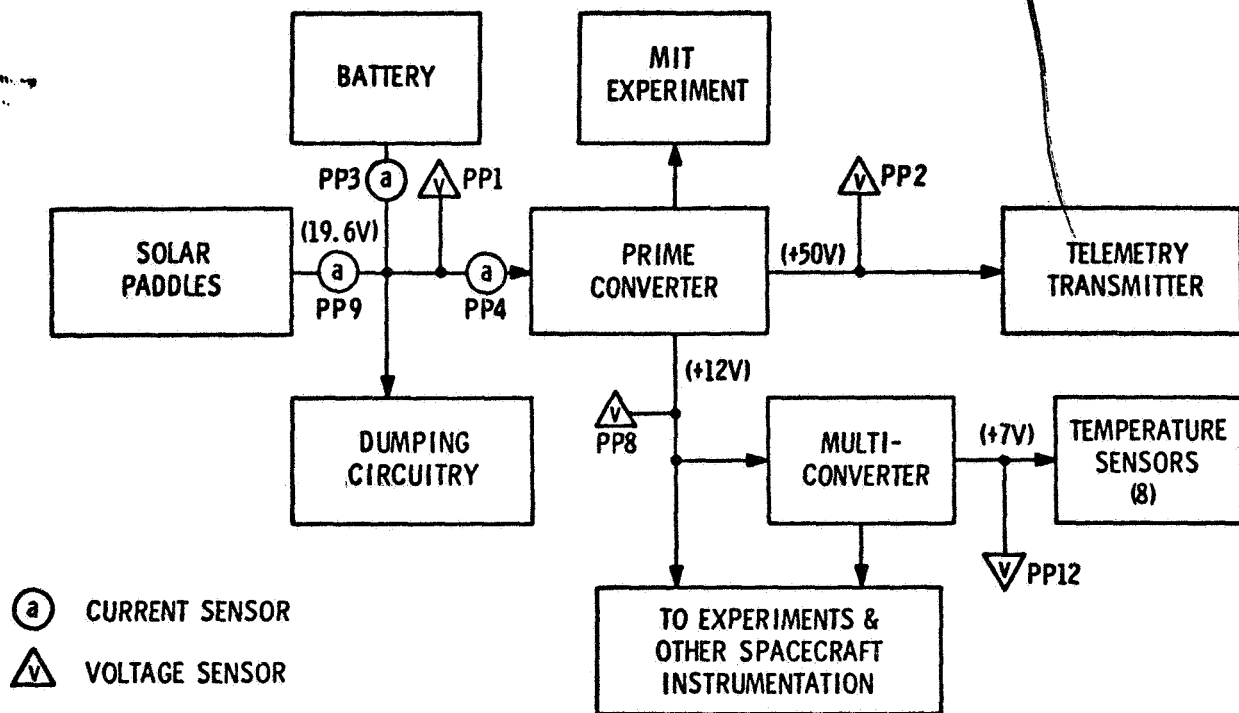


Figure 6 - IMP III Power Performance Parameters

Accordingly all data and graphs presented herein will be based on the "corrected" data.

Power System Data

The solar paddle output current and spacecraft load current are shown as a function of days after launch in Figure 8. All currents are measured with the main bus voltage at 18.3 volts. The decrease of spacecraft current (PP4) occurring about 50 days after launch corresponds to about 2.5 watts*. Careful scrutiny of the performance parameter data has not revealed an explanation for this as yet.

The solar paddles produced an average of about 45 watts initially at a spin axis-sun angle of 31° (i.e., 31° from the Rb Magnetometer). This level of output

*Data mentioned herein are the adjusted data; i.e., they include a correction factor for calibration drift.

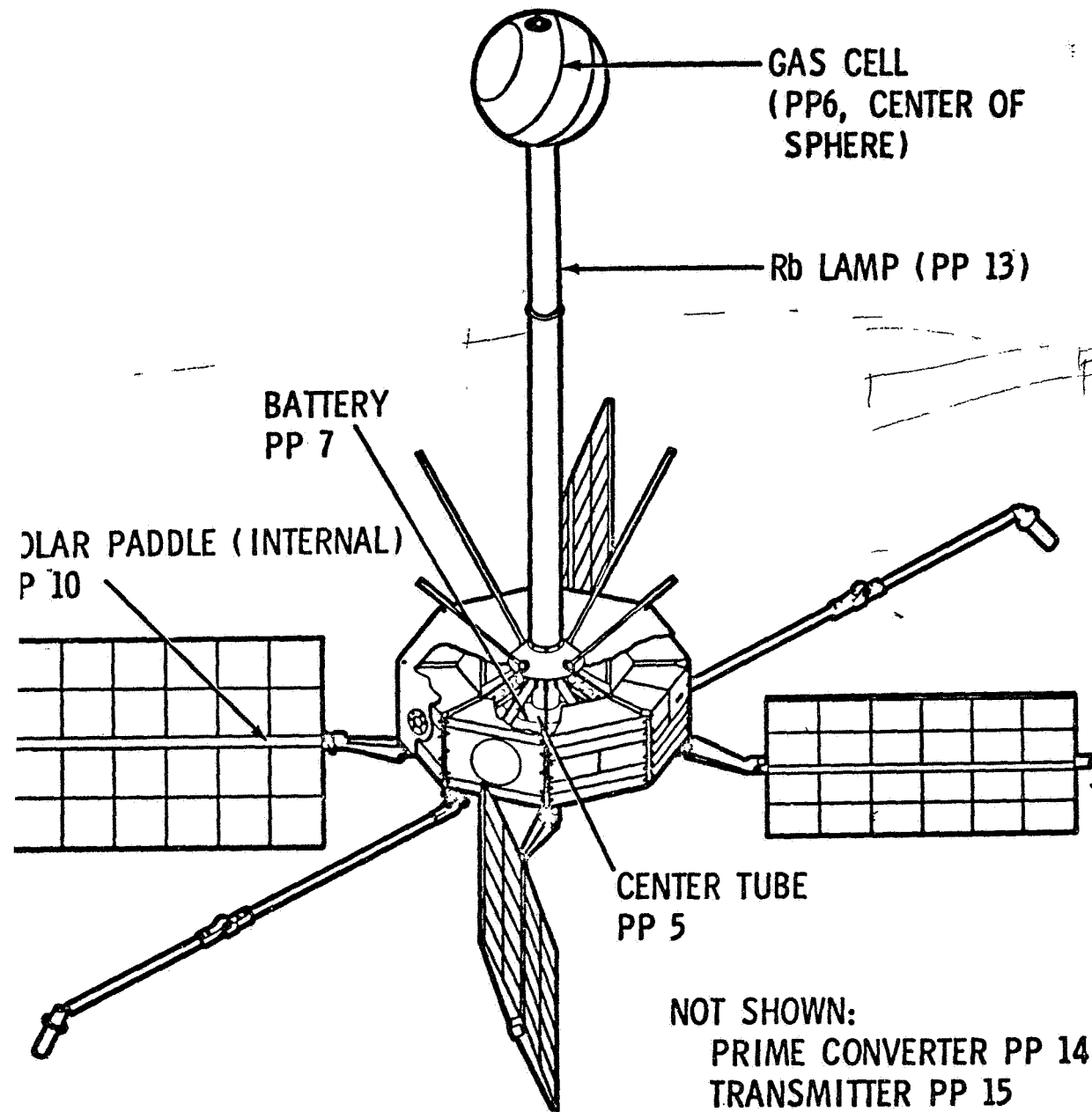


Figure 7 - IMP III Temperature Measurement Locations

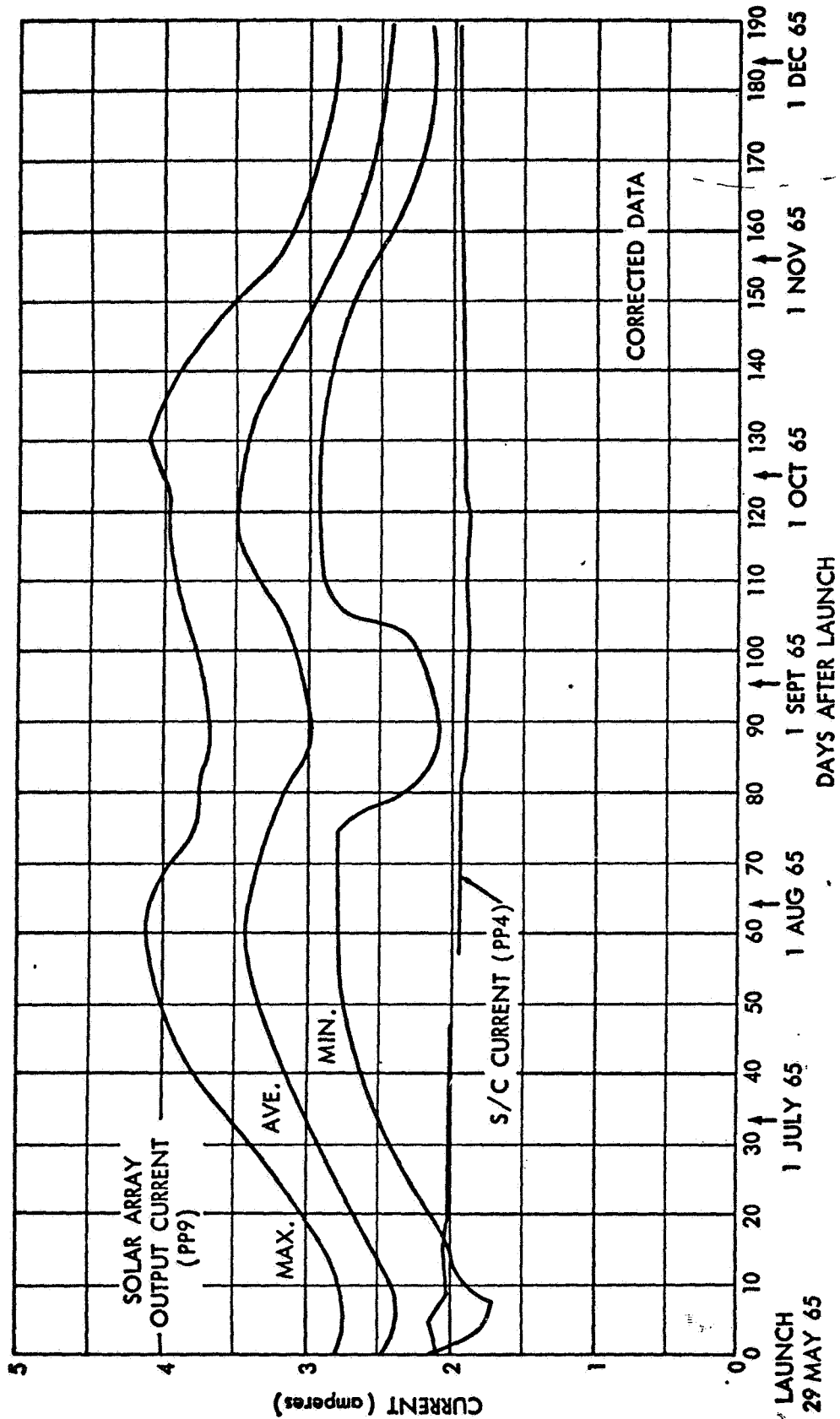


Figure 8 - Explorer XXVIII Currents vs Days After Launch

agreed closely with the predictions for that Sun angle (Figure 9). A maximum output of 64 watts occurred four months after launch. The variation of paddle output as the satellite spins is shown in Figure 8. For example, at a spin axis-sun angle of about 35 degrees (shortly after launch) the peak to peak variation was 16½ watts; at a sun angle of 90 degrees, the variation was 29½ watts. During the six-month period following launch the power output followed the predictions though decreasing somewhat due to radiation degradation.

IMP III is the first of the series to use N on P solar cells as well as a more effective (though thinner) protective glass covering. It is difficult to determine quantitative degradation with a reasonable accuracy until data is obtained at identical sun angles. One year after launch, the sun angle will be approximately the same as at launch and degradation of power output can be determined directly. Until then suffice it to say that the IMP III paddle degradation appears to be considerably less than that encountered on IMP's I and II (which used P on N solar cells). This can be seen by comparing Figure 9 with the corresponding curves for previous IMP's (Reference 2 and 3). The telemetered data of the regulated voltages PP1, 2, 8 and 12 (Figure 6) indicates that these voltages remained within acceptable limits at all times.

Temperature Data

For the first six months, the temperatures of the Battery, Prime Converter and Transmitter (and hence most, if not all, experiments and electronics mounted within the octagon) remained within the range of + 5°C to + 50°C (Figure 10). The solar paddles maintained temperatures from - 37°C to - 12°C. This is substantially colder than previous IMP Paddle temperatures and is due to the difference in absorptivity/emmissivity characteristics of N/P cells compared to the old-type P/N cells. The temperature of two components of the Rb Magnetometer are telemetered: the first, the Gas Cell is thermally controlled by an electrical heater. Operation was satisfactory, the gas cell temperature was maintained at $40 \pm 1^\circ\text{C}$ throughout the first 6 months. The second component - the Rb Lamp is heated by self-dissipation. The initial temperature was + 83°C which slowly increased to a maximum value of 92°C some 160 days later. This Lamp, a modified version of previous ones, produced a constant light intensity, being on 100% of the time and eliminated the need for an electrical heater as flown on IMP's I and II (Reference 15).

The predicted and actual temperatures of the Battery, Prime Converter, Transmitter and Solar Paddles are compared in Figures 11 thru 14.

In general, the correlation of actual temperatures with predictions was quite good. The thermal control design maintained all temperatures well within maximum tolerable ranges.

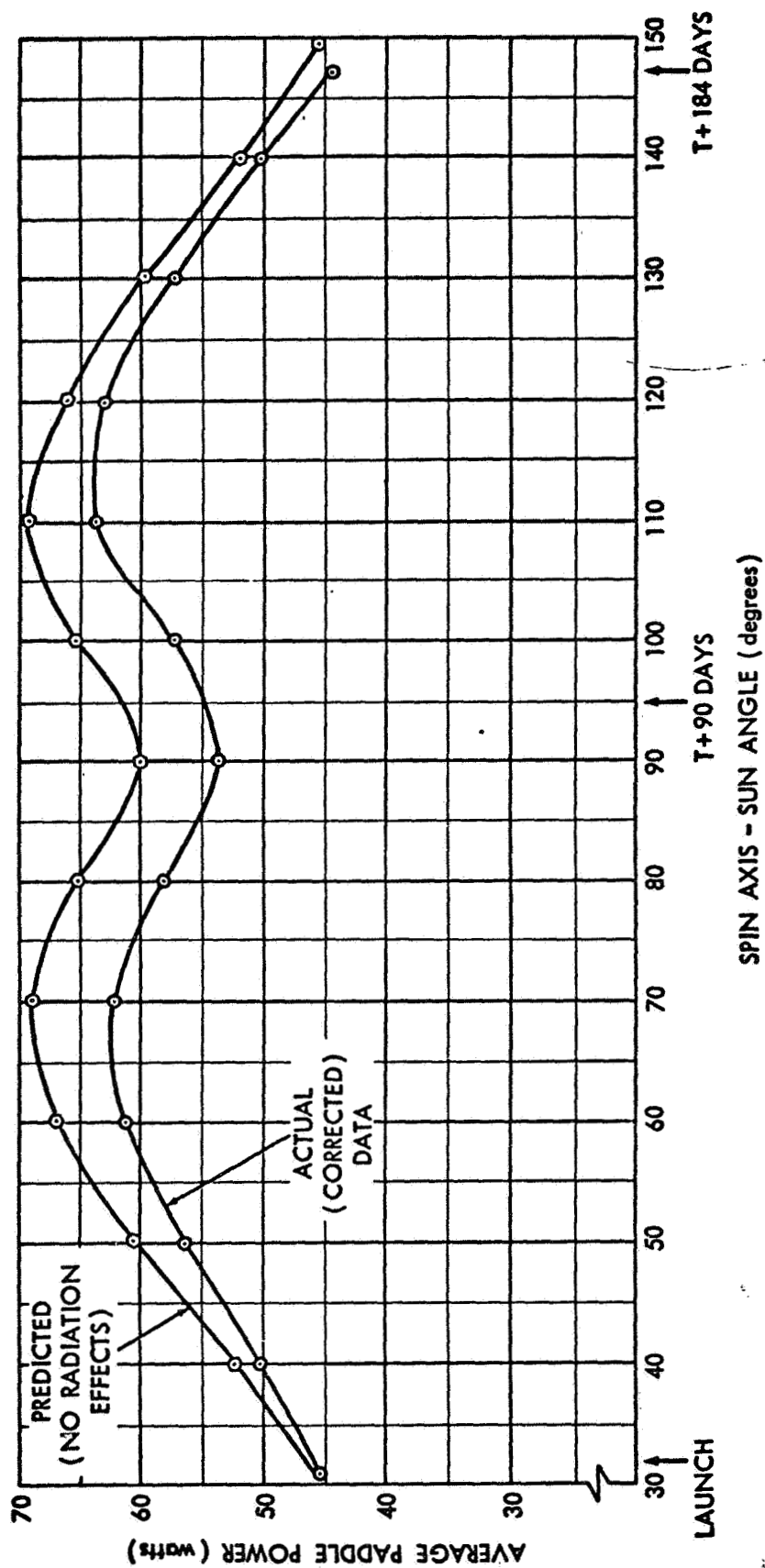


Figure 9 - IMP III - Explorer XXVIII Solar Paddle Output Power

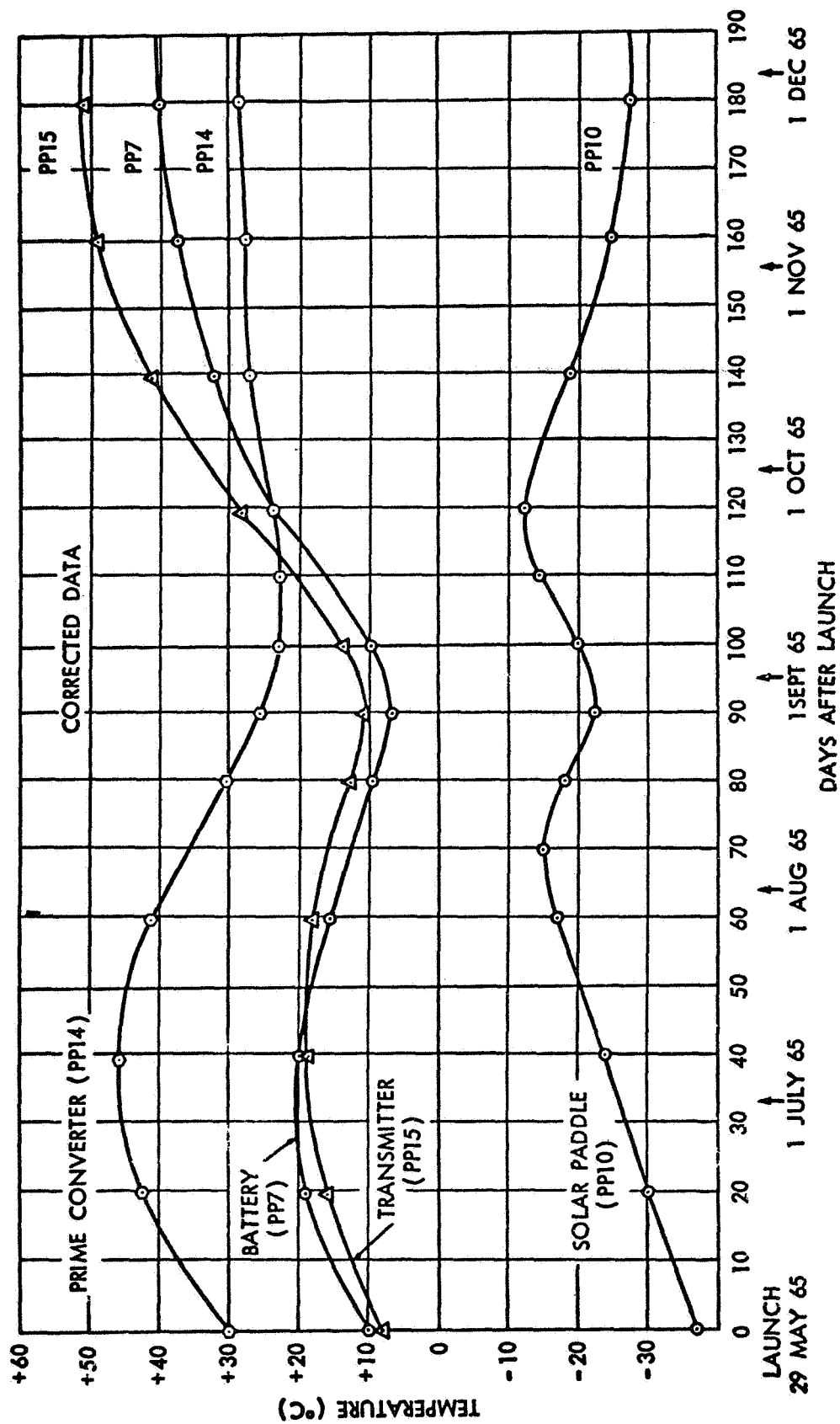


Figure 10 - IMP III - Explorer XXVIII Temperatures vs Days After Launch

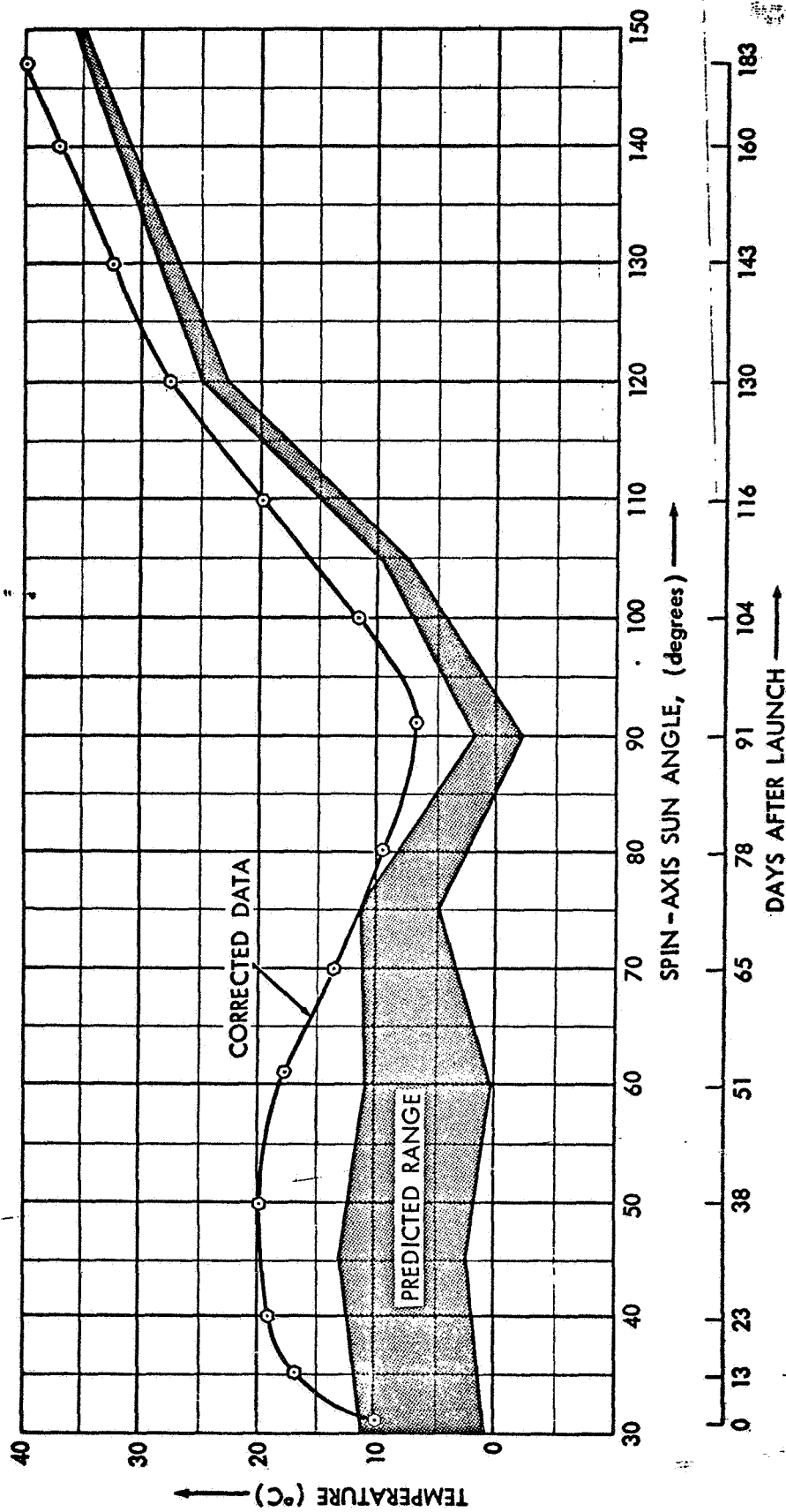


Figure 11 - IMP III - Explorer XXVIII Battery Temperature

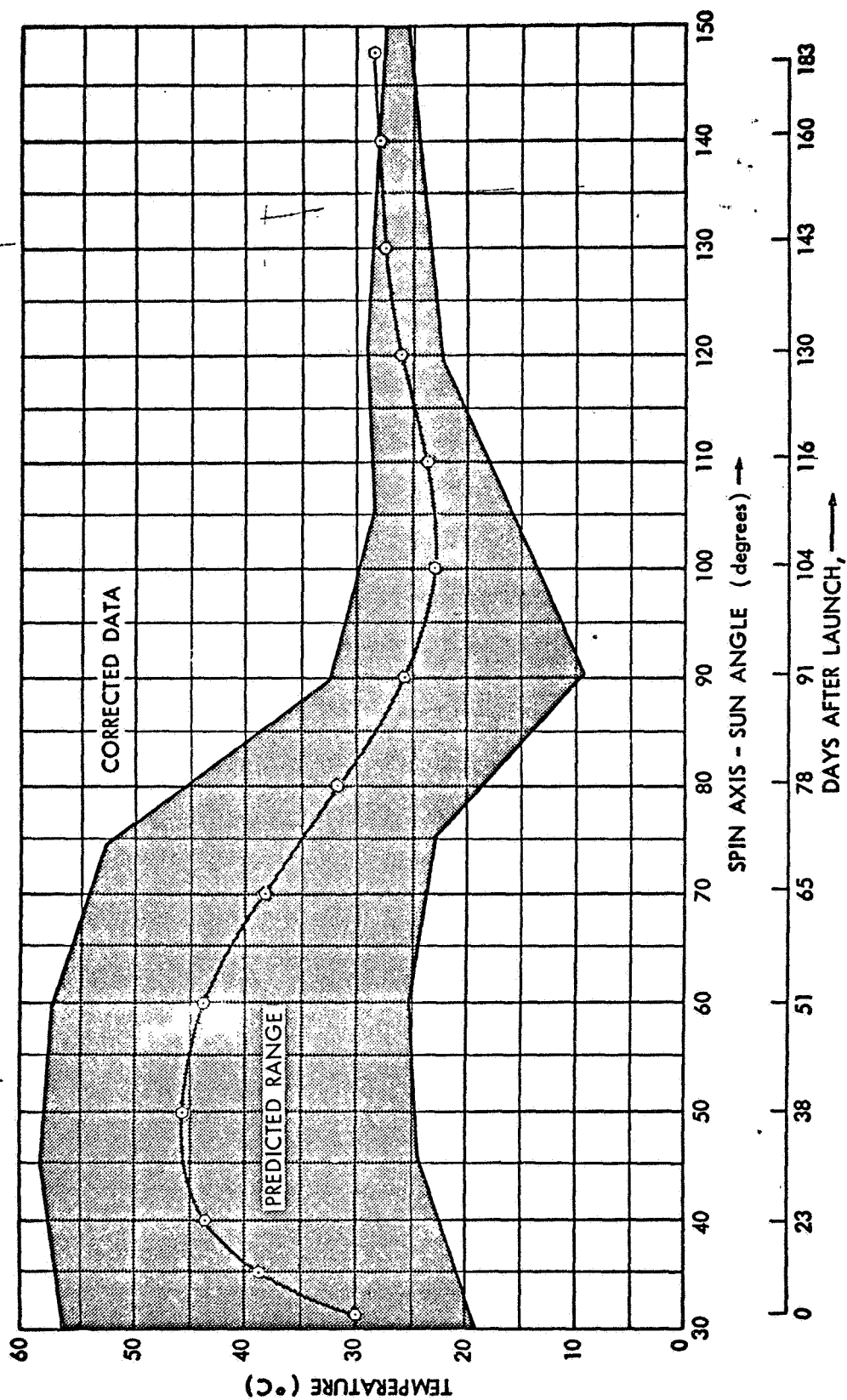


Figure 12 -- IMP III - Explorer XXVIII Prime Converter Temperature

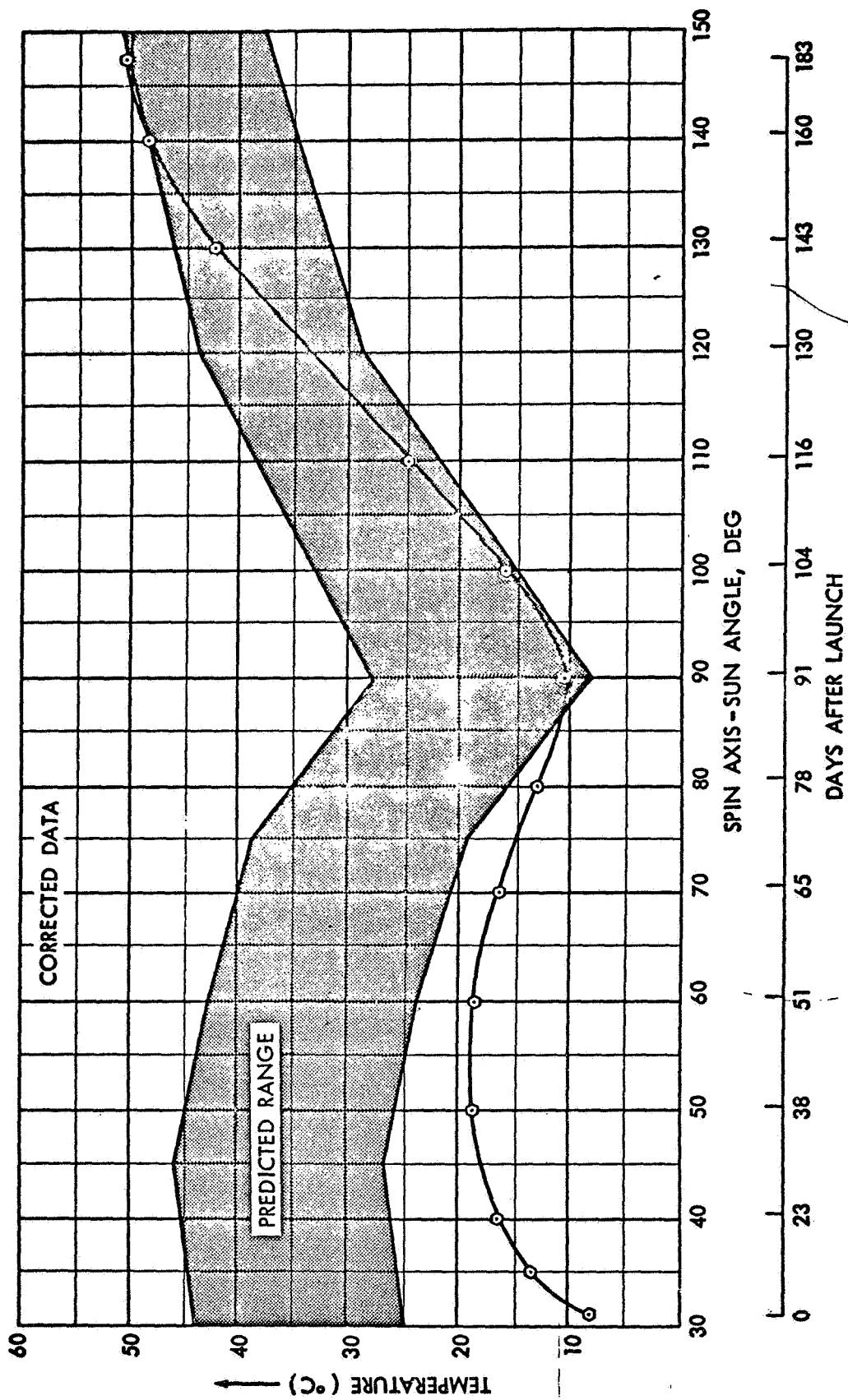


Figure 13 - IMP III - Explorer XXVIII Transmitter Temperature

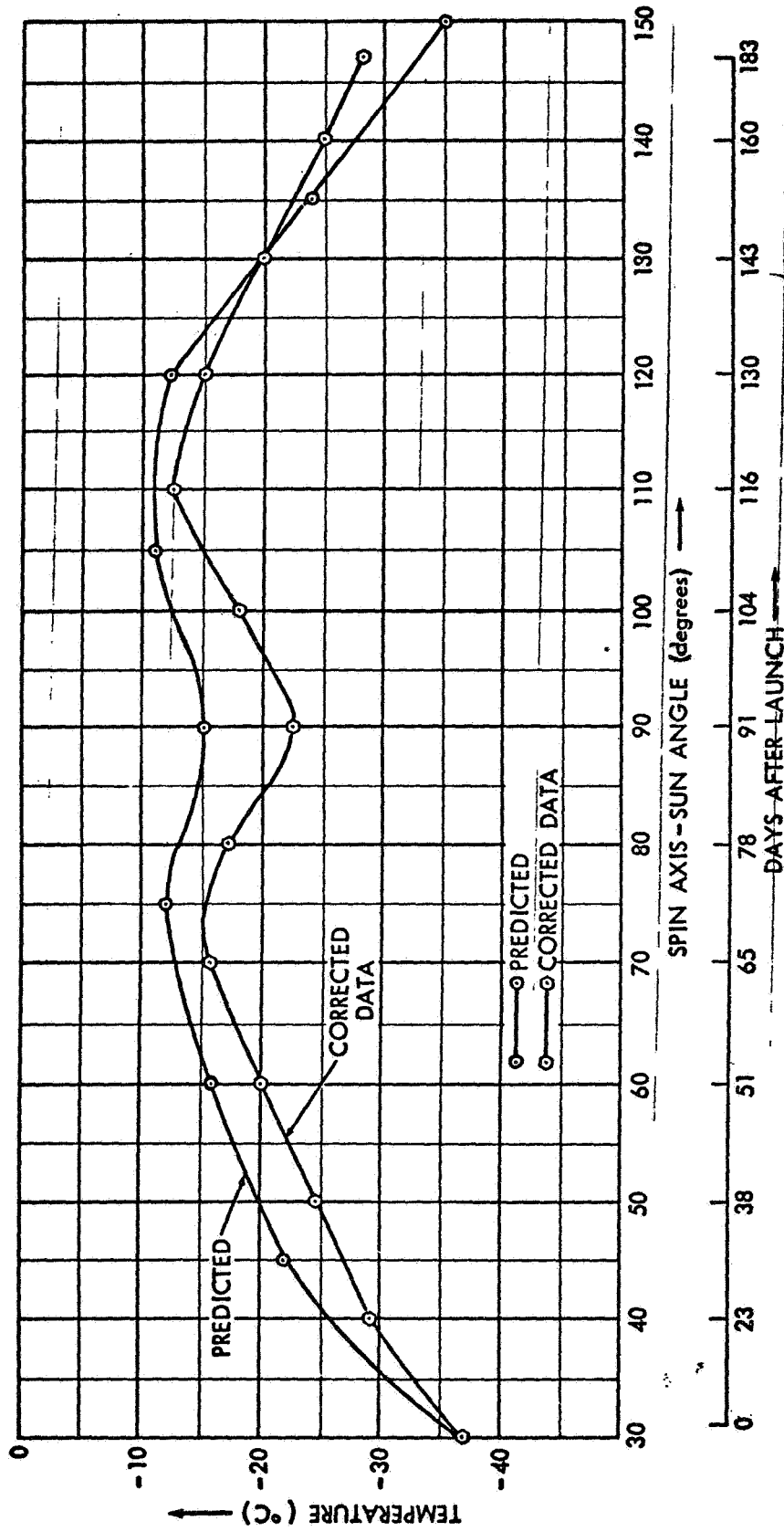


Figure 14 - IMP III - Explorer XXVIII Solar Paddle Temperature

Although no temperature measurements of an "average temperature" are telemetered, Figure 15 shows the predicted temperature for an average facet location - typical of a facet in which no high power dissipation components are mounted.

CONCLUDING REMARKS

The IMP III spacecraft, launched on 29 May 1965 has operated continuously to the present (March, 1966). Two of nine experiments (both solar plasma detectors) failed to produce useable data. The remaining experiments continue to produce excellent quality data.

Although the period discussed in this report is restricted to the first six months of operation, a few later statistics are relevant: as of 24 February 1966 the spacecraft completed 47 orbits and 271 days (6500 hours) of continuous operation. The Space Tracking and Data Acquisition Network had recorded a total of 7320 hours of data (including overlaps).

The spacecraft power, telemetry, rf and thermal systems have performed flawlessly except for an occasional spurious command-off of the S/C transmitter. However, only a few hours of data have been lost due to this anomaly. All experiments except for the MIT Plasma Probe (which failed at launch) and the Ames Proton Analyzer (time of failure uncertain) continue to operate satisfactory.

The orientation and eccentricity of the orbit are such that an extended shadow period (of over 5-1/2 hours) has been predicted for 6 April 1966. This event will be watched with much interest since it will provide a battery capacity check thereby shedding additional light on the adequacy of the power system changes incorporated in IMP III; in addition it presents a formidable obstacle to the continued operation of the spacecraft.

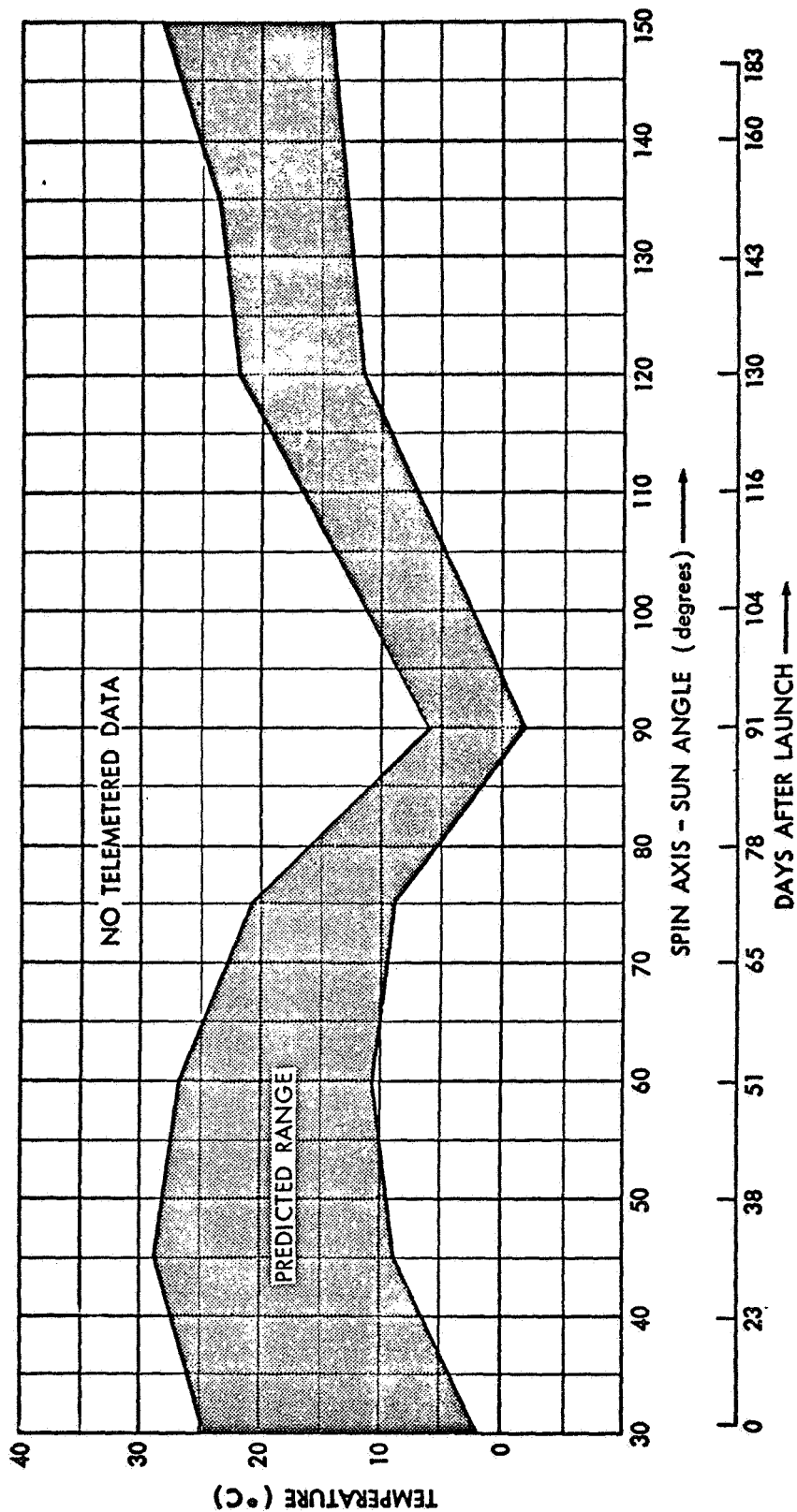


Figure 15 - IMP III - Explorer XXVIII Average Facet Temperature

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13. Private communication with Dr. J. H. Wolfe, Nov., 1965.
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APPENDIX A

Design Changes Incorporated in the IMP III Spacecraft

A vast number of minor changes were incorporated into the IMP C spacecraft as part of the updating procedure following the IMP II launch. In general, these changes were electrical component changes incorporated in new or spare assemblies to further refine or improve a circuit previously flown on IMPs I and/or II. These are not described herein.

A number of more important changes, and their effect on S/C operation follow:

1. Despin System

Previous IMP spacecrafts did not employ a despin function. In those flights, the third-stage — spacecraft combination was spun up to about 75 RPM during third stage burning. This spin rate was deemed to be high enough to provide stability and yet slow enough to permit the attainment of a nominal orbital spin rate of 20 RPM merely by the erection of the solar paddles and booms following burn-out.

However, because of the somewhat unpredictable dynamical characteristics of the X-258, a higher initial spin rate ($\sim 140 \pm 10$ RPM) was desired for the IMP III mission. This necessitated the addition of a Despin System to reduce the spin rate following burn-out to about 75 RPM so that paddle and boom erection would further reduce the spin rate to the desired final value.

To implement this, the standard Yo-Yo weight and wire device as used on previous GSFC Explorers was added. The actuation of the dimple motors to release the weights was initiated by redundant electronic timers installed in the Programmer Card (IG5). The timers were started by the breaking of an electrical ground occurring at vehicle umbilical separation at lift-off. The nominal timer setting was $420 \pm 2\%$ seconds.

Operation was as planned; from AGC records, despin occurred at $T + 418.3$ seconds. Analysis of the flight history (Reference 7) reaffirmed the desirability of using a higher spin rate and the Yo-Yo system as a means of reducing the displacement of the spin axis from the velocity vector.

2. Transmitter Filter

A filter was added between the Transmitter and the Antenna to improve the sensitivity of the Range and Range Rate receiver for large earth-to-spacecraft distances.

Operation has been satisfactory and, in light of the higher than nominal orbit achieved, the filter was a fortunate addition.

3. Solar Paddles

The IMP III paddles were a new design and produced by a new manufacturer. A summary of the characteristics is shown below:

| | IMP III | IMPs I and II |
|-------------------------------|---------------|---------------|
| Cell type | N/P | P/N |
| Cell size (cm) | 2 x 2 | 1 x 2 |
| Glass thickness (mills) | 6 | 12 |
| Overall size (inches) | 20-1/8 x 27.6 | 20-1/8 x 26 |
| Weight per paddle (grams) | 2400 | 3000 |
| Power output per side (watts) | 33.6 | 33.6 |

The most important improvements were the reduction in weight — a savings of 5.3 pounds per set of four and the N/P cells which are less susceptible to radiation degradation.

Operation has been satisfactory. Radiation damage has been less (as expected) than encountered in IMPs I and II.

4. Battery Charge Control Circuitry

The silver cadmium batteries employed on IMP (as well as most previous explorers where low magnetic background is a necessity) are subject to damage / overcharging which can and does occur in an IMP-type application.

Because of the eccentric orbit, the occurrence of shadow periods and hence battery usage is relatively infrequent. Therefore the Battery is subjected to long periods of trickle charge at the previously standard operating voltage of 19.6 volts. It was recently proven by the GSFC Electrochemical Power Sources Section that this long-term trickle charge causes the buildup of excessive internal gas pressure in the cells which in many cases forces the electrolyte out of the cell resulting in battery failure.

A technique for controlling the charging voltage applied to the battery as a function of the state-of-charge of the battery was proposed by the EPS Section. Despite the lateness of the hour (only a few months before launch) it was decided that this departure from conventional power system design must be incorporated in the IMP III spacecraft if a battery failure was to be avoided.

Basically, the technique works as follows: the Solar Array Regulator regulates the output voltage of the solar paddles at one of two discrete voltage levels: 19.6 volts or 18.3 volts. The Performance Parameter Card measures the Battery charge current; a schmidt trigger was added to this card to provide a signal (to the Solar Array Regulator) whenever the Battery current was below 100 milliamperes. The presence or absence of this signal determines which of the two voltage levels will be maintained.

In summary, when the Battery current is greater than 100 ma (called the "trip point") the performance parameter card furnishes no signal to the Solar Array Regulator and so a charging voltage of 19.6 volts is maintained (the same as previous designs). However, when the Battery current decreases to a value less than 100 ma, (implying a nearly charged condition) a signal to the Solar Array Regulator causes the voltage to be reduced to 18.3 volts which is approximately the open-circuit voltage of the battery, and hence charging ceases. Therefore no overcharge, no pressure build up within the cells, no leaks, no Battery failure, no spacecraft failure.

In-flight operation so far has equaled the highest of hopes. The system has worked satisfactorily—there being several observed trip points at about 110 ma following shadow periods as the battery recharged; the charge voltage has been maintained at the lower level throughout 99+% of the first six months, and there is no evidence suggesting that the condition of battery is anything but perfect after six months in orbit.

5. Undervoltage System

The Undervoltage lock-out point (system voltage below which everything is turned off) was changed from 12.0 volts to 11.5 volts to permit better low temperature operation.

The recycle time was shortened from 8 hours to 3 hours since under normal conditions the battery can attain 90% recharge after 3 hours.

There have been no under-voltage turnoffs during the first six months in orbit and so neither of the above functions have been called upon to operate.

6. Thermal Control

The spring seat cover coating was changed from buffed aluminum to white paint in order to reduce the temperature of the battery below that experienced on IMP II. In-flight data shows that this change resulted in a net decrease of 10°C.

7. Experiments

The Rb Vapor Magnetometer, the E vs dE/dx , the University of Chicago R vs dE/dx , the Ames Proton Analyzer and the MIT Plasma Probe were modified in varying degrees for the IMP III flight (Reference 15). The basis for these modifications were obtained during development, test and flight of the previous IMP's and in some cases constituted internal redesigns but maintaining invariant interfaces with the spacecraft proper.

APPENDIX B

IMP III - Explorer XXVIII Summary Data Sheet

SPACECRAFT

WEIGHT: 128.46 lbs. (lift-off weight)

EXPERIMENT WGT.: 44.3 lbs. (34.5%)

STRUCTURE + INSTR.: 84.2 lbs. (65.5%)

C. G.: 7.675" above separation plane

MOMENTS OF INERTIA:

ROLL = 10.73 slug-ft²

TRANSMAX = 9.84 slug-ft²

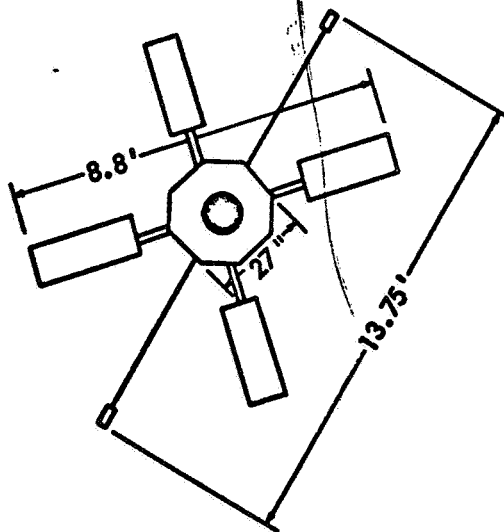
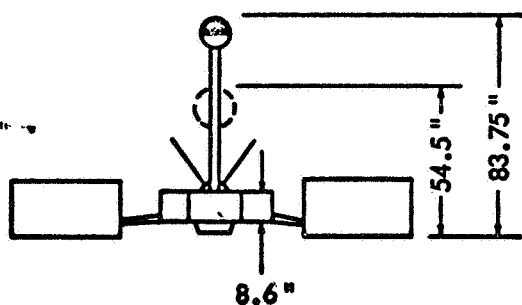
RATIO = 1.09

ORBITAL SPIN RATE: 23 ± 5 rpm

POWER REQUIREMENTS: 38.4 watts @ 18.3V

POWER: N/P solar cells, SILCAD battery

TRANSMITTER: PFM, 4 watts @ 136.125 M/C



MISSION

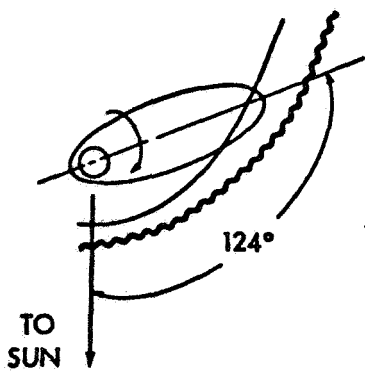
To study in detail, the radiation environment of the Earth's magnetosphere, the transition region and interplanetary space and the properties of the interplanetary magnetic field. Included are energetic particle, solar wind, solar and galactic cosmic ray and magnetic field experiments.

LAUNCH

Three stage, Delta Vehicle DSV-3C (with X-258) #31. Performance above nominal, injection velocity 35,712 fps. About 20.5° "tip-off" away from nominal orientation. Launch site, Cape Kennedy, 29 May 1965, 0700:00 EST.

ORBIT

(INITIAL PARAMETERS)



Perigee height - 208 km Period - 140 hours
Apogee height - 260,800 km $i = 33.94^\circ$
Semi-major axis - $21.5 R_E$ $e = .952$
Extended Shadow ($\sim 5\text{-}1/2$ hrs.) expected early
April, 1966
Tracking: Range and Range Rate and Minitrack.

EXPERIMENTS (9)

Solar Wind (2), Cosmic Ray (2), Energetic Particles (3), Magnetic Fields (2).
Contributed by Ames, U. California, U. Chicago, MIT, GSFC (5).

RESULTS

Operation continues after 9 months; two Solar Wind experiments failed to provide any data, relatively minor problems with U. of Chicago Cosmic Ray experiment and GSFC Magnetic Field experiments (one Fluxgate channel failed during launch). Slight coning (2 degrees) beginning about 110 days after launch. Two-level battery charge scheme working flawlessly.